

Tactical Combat Casualty Care in Special Operations



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by

Captain Frank K. Butler, Jr., MC, USN

Lieutenant Colonel John Haymann, MC, USA

Ensign E. George Butler, MC, USN

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CAPT Frank K. Butler, Jr., MC USN*
LTC John Hagmann, MC USA†

ENS E. George Butler, MC USN‡

U.S. military medical personnel are currently trained to care for combat casualties using the principles taught in the Advanced Trauma Life Support (ATLS) course. The appropriateness of many of the measures taught in ATLS for the combat setting is unproven. A 1-year study to review this issue has been sponsored by the United States Special Operations Command. This paper presents the results of that study. We will review some of the factors that must be considered in caring for wounded patients on the battlefield with an emphasis on the Special Operations environment. A basic management protocol is proposed that organizes combat casualty care into three phases and suggests appropriate measures for each phase. A scenario-based approach is needed to plan in more detail for casualties on specific Special Operations missions, and several sample scenarios are presented and discussed.

Introduction

Medical training for Special Operations forces (SOF) corpsmen and medics is currently based on the principles taught in the Advanced Trauma Life Support (ATLS) course.¹ The ATLS guidelines provide a standardized, systematic approach to the management of trauma patients that has proven very successful when used in the setting of civilian hospital emergency departments, but the efficacy of at least some of these measures in the prehospital setting has been questioned.²⁻²⁹

Even less certain is the appropriateness of extrapolating ATLS guidelines without modification to the battlefield: some of the shortcomings of ATLS in the combat environment have been addressed by military medical authors.^{21,30-36} The prehospital phase of caring for combat casualties is critically important, since up to 90% of combat deaths occur on the battlefield before the casualty ever reaches a medical treatment facility (MTF).³⁷ The importance of this issue was recognized by the Commander of the Naval Special Warfare Command in 1993 when he called for a study on combat casualty care techniques in Special Operations. The need for this research was validated by the United States Special Operations Command (USSOCOM). A 2-year study of this issue was subsequently funded by USSOCOM and accomplished through literature reviews and multiple workshops with SOF physicians, corpsmen, and medics. This paper presents the results of that study. A parallel and independent effort was found to be underway in the United Kingdom, where a modified ATLS-type course is being developed for use by the British Special Air Service and Special Boat Squadron (personal

communication, Dr. John Navein, former Senior Medical Officer, 22nd Special Air Service Regiment).

Figures 1 through 4 describe several representative casualty scenarios that might be encountered in the conduct of Special Operations and illustrate the complexity of the casualty care that must be rendered by SOF corpsmen and medics. The need to consider significant modifications to the principles of care taught in ATLS is obvious when considering the management of these scenarios. Factors such as enemy fire, medical equipment limitations, a widely variable evacuation time, tactical considerations, and the unique problems entailed in transporting casualties that occur in Special Operations all must be addressed. In addition, greater emphasis needs to be placed on the management of penetrating trauma, since most deaths in a combat setting are caused by penetrating missile wounds.³⁰ Although the Department of Defense is aggressively pursuing new technologies that may result in improved management of combat trauma,³⁸ the most important aspect of caring for trauma victims on the battlefield is well-thought-out planning for that environment and appropriate training of combat medical personnel.

Initial training for SOF corpsmen and medics is currently conducted at the 18 Delta Medical Sergeants Course taught at Fort Sam Houston in San Antonio, Texas, although a move to the new Special Operations Medical Training Center in Fort Bragg, North Carolina, is planned for the near future. The 18 Delta course structures its trauma care around the principles taught in ATLS. These principles are supplemented by trauma care training in a field environment, but the departures from ATLS appropriate for the battlefield have not been systematically reviewed and presented in the literature. In addition, many of the unique operating environments and missions encountered in Special Operations are not addressed. Another consideration is skills maintenance. After completion of their initial training, SOF corpsmen and medics are generally assigned to small operational units (SEAL platoons or Special Forces A teams), which are required to conduct training in a wide variety of combat skills and to participate in numerous training exercises and operational deployments. Usually lacking from this intense training regimen is an ongoing exposure to victims of penetrating trauma, so the skills learned in their initial combat trauma care training are very infrequently utilized in the absence of armed conflicts. Some individuals attempt to supplement their unit training with rotations in a trauma center or by moonlighting as paramedics, but the intense operational tempo maintained in most SOF units has historically severely limited the effective use of either of these options.

Bearing these considerations in mind, this paper will begin by attempting to describe a basic casualty-management protocol that is appropriate for the battlefield. Necessary modifications to the basic management protocol will then be discussed for each of the four scenarios mentioned previously.

*Naval Special Warfare Command, Detachment Pensacola, Naval Hospital, Pensacola, FL 32512.

†Casualty Care Research Center, Uniformed Services University of the Health Sciences, Bethesda, MD 20814.

‡Uniformed Services University of the Health Sciences, Bethesda, MD 20814.

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Ship attack operation launched from coastal patrol craft 12 miles out
 One-hour transit **in** two Zodiac rubber boats
 Seven **swim** pairs of SEALs
 Zodiacs get **within** 1 mile of the harbor
 78°F water (divers wearing wet suits)
 Surface swim for a half-mile, then begin dive with closed-circuit oxygen SCUBA
 One swimmer shot **in** the chest by patrol boat as he surfaces to check his bearings in the harbor
 Wounded diver conscious

Fig. 1. Scenario 1.

Twelve-man Special Forces team
 Interdiction operation for weapons convoy
 Night parachute jump from a C-130 aircraft
 Four-mile patrol over rocky terrain to the objective
 Planned helicopter extraction near target
 One jumper sustains an open fracture of his left tibia and fibula on landing

Fig. 2. Scenario 2.

Stages of Care

In making the transition from the standards of ATLS to the SOF tactical setting, it is useful to consider the management of casualties that occur during SOF missions as being divided into three distinct phases.

1. "Care under fire" is the care rendered by the medic or corpsman at the scene of the injury while he and the casualty are still under effective hostile fire. Available medical equipment is limited to that carried by the individual operator or by the corpsman or medic in his medical pack.

2. "Tactical field care" is the care rendered by the medic or corpsman once he and the casualty are no longer under effective hostile fire. It also applies to situations in which an injury has occurred on a mission but there has been no hostile fire. Available medical equipment is still limited to that carried into the field by mission personnel. Time prior to evacuation to an MTF may vary considerably.

3. "Combat casualty evacuation care" is the care rendered once the casualty (and **usually** the rest of the mission personnel) have been picked up by an aircraft, vehicle, or boat. Additional medical personnel and equipment that have been pre-staged in these assets should be available at this stage of casualty management. The term "CASEVAC" (for combat casualty evacuation) should be used to describe this phase instead of the commonly used term "MEDEVAC" for reasons that will be explained below.

Basic Tactical Combat Casualty Management Plan

Having identified the three phases of casualty management in a tactical setting, the next step is to outline in a general way the care that is appropriate to each phase. The basic tactical casualty management plan described below is presented as a generic sequence of steps that **will** probably require modification in some way for almost any casualty scenario encountered in Special Operations. This is expected and necessary, but the basic plan is important as a starting point from which development of specific management plans for the scenarios to be discussed later may begin.

Care under Fire

A more complete description of the SOF tactical setting will help provide a better understanding of the rationale for the recommendations made for this phase. Care under fire will typically be rendered during night operations and will take place in the middle of an active engagement with hostile forces. The corpsman will be hampered by severe visual limitations while caring for the casualty, since the use of a white light on the battlefield will identify his position to the enemy and is not generally recommended. Night-vision devices may provide some assistance, but they are not always carried on night operations because of weight and other considerations.

SOF medical personnel carry small arms with which to defend themselves in the field. In small-unit operations, the additional **firepower** provided by the corpsman or medic may be essential in obtaining tactical fire superiority. The risk of injury to other patrol personnel and additional injury to the previously wounded operators will be reduced if immediate attention is directed to the suppression of hostile fire. The corpsman or medic may therefore initially need to assist in returning fire instead of stopping to care for the casualty. The best medicine on any battlefield is **fire** superiority. As soon as he is directed or is able to render care, keeping the casualty from being wounded further is the first major objective. Wounded SOF operators who are unable to participate further in the engagement should lay flat and still if any ground cover is available or move as quickly as possible to nearby cover if able. If there is no cover and the casualty is unable to move himself to **find** cover, he should remain motionless on the ground so as not to draw more fire. There are **typically** only one or two corpsmen or medics present on small-unit SOF operations. If they sustain injuries, no other

Twenty-four-man Special Forces assault team
 Night assault operation on hostile position in dense jungle
 Estimated **hostile** strength is 15 men with automatic weapons
 Insertion from **riverine** craft
 Three-mile patrol to target
 As patrol reaches **objective** area, a booby trap is tripped, resulting **in** a dead point man and a patrol leader with massive trauma to one leg
 Heavy incoming fire as **hostiles** respond
 Planned extraction is by boat at a point on the river a half-mile from the target

Fig. 3. Scenario 3.

Sixteen-man SEAL patrol
 Planned interdiction operation in arid, mountainous Middle Eastern terrain
Two trucks with SAM missiles expected **in** convoy
 Estimated hostile strength is 10 men with automatic weapons in accompanying vehicle
 Helicopter insertion/extraction
 Six-mile patrol to target
 Planned extraction close to ambush site
 While patrol is in ambush **position**, one patrol member is bitten on the leg by an unidentified snake
 Over the next 5 minutes, the bitten SEAL becomes dizzy and confused
 Target convoy expected in approximately 1 hour

Fig. 4. Scenario 4.

medical personnel will be available until the time of extraction in the CASEVAC phase. With these factors in mind, the proposed management of casualties in this phase is contained in Figure 5.

No immediate management of the airway should be anticipated at this time because of the need to move the casualty to cover as quickly as possible. It is very important, however, to stop major bleeding as quickly as possible, since injury to a major vessel may result in the very rapid onset of hypovolemic shock. The importance of this step requires emphasis in light of reports that hemorrhage from extremity wounds was the cause of death in more than 2,500 casualties in Vietnam who had no other injuries.³⁹ These are preventable deaths. If the casualty needs to be moved, as is usually the case, a tourniquet is the most reasonable initial choice to stop major bleeding. Although ATLS discourages the use of tourniquets, they are appropriate in this instance because direct pressure is hard to maintain during casualty transport under fire. Ischemic damage to the limb is rare if the tourniquet is left in place for less than 1 hour, and tourniquets are often left in place for several hours during surgical procedures. In any event, in the face of massive extremity hemorrhage it is better to accept the small risk of ischemic damage to the limb than to lose a casualty to exsanguination. Both the casualty and the corpsman or medic are in grave danger while a tourniquet is being applied in this phase, and non-life-threatening bleeding should be ignored until the tactical field care phase. The decision regarding the relative risk of further injury versus that of exsanguination must be made by the corpsman or medic rendering care. The need for Immediate access to a tourniquet in such situations makes it clear that all SOF operators on combat missions should have a suitable tourniquet readily available at a standard location on their battle gear and be trained in its use. This may enable them to quickly put a tourniquet on themselves if necessary without sustaining further blood loss while waiting for medical assistance.

Transport of the casualty will often be the most problematic aspect of providing tactical combat casualty care. Although the civilian standard of care is to immobilize the spinal column prior to moving a patient with injuries that might have resulted in damage to the spine, this practice needs to be re-evaluated in the combat setting. Arishita et al. examined the value of cervical spine immobilization in penetrating neck injuries in Vietnam and found that in only 1.4% of patients with penetrating neck injuries would immobilization of the cervical spine have been of possible benefit.² Since the time required to accomplish cervical spine immobilization was found to be 5.5 minutes, even when using experienced emergency medical technicians, the authors concluded that the potential hazards to both patient and provider outweighed the potential benefit of immobilization.^{2,21} Kennedy et al. similarly found no cervical spine injuries in 105 gunshot wound patients with injuries limited to the calvaria.⁴⁰ Parachuting injuries, fast-roping injuries, falls, and other types

1. Return fire as directed or required
2. Try to keep yourself from getting shot
3. Try to keep the casualty from sustaining additional wounds
4. Stop any life-threatening external hemorrhage with a tourniquet
5. Take the casualty with you when you leave

Fig. 5. Basic tactical casualty management plan phase one: care under fire.

of trauma resulting in neck pain or unconsciousness should still be treated with spinal immobilization unless the danger of hostile fire constitutes a greater risk in the judgment of the treating corpsman or medic.

Standard litters for patient transport are not typically carried into the field on direct-action Special Operations missions because of their weight and bulk. Transport of the patient is currently accomplished with a shoulder carry or improvised litter. Since there will often be only 8 to 10 men on the operation, having additional operators engaged in transporting a wounded patient any significant distance presents a major problem. There should be no attempt to save the casualty's rucksack unless it contains items that are still critical to the mission. His weapons and ammunition should be taken if at all possible.

Tactical Field Care

The proposed management plan for the tactical field care phase is described in Figure 6. This phase is distinguished from the care under fire phase by more time with which to render care and a reduced level of hazard from hostile fire. The amount of time available to render care may be quite variable. In some cases, tactical field care will consist of rapid treatment of

1. Airway management
 - Chin-lift or jaw-thrust
 - Unconscious casualty without airway obstruction: nasopharyngeal airway
 - Unconscious casualty with airway obstruction: cricothyroidotomy
 - Cervical spine immobilization is not necessary for casualties with penetrating head or neck trauma
2. Breathing
 - Consider tension pneumothorax and decompress with needle thoracostomy if a casualty has unilateral penetrating chest trauma and progressive respiratory distress
3. Bleeding
 - Control any remaining bleeding with a tourniquet or direct pressure
4. N
 - Start an 18-gauge N or saline lock
5. Fluid resuscitation
 - Controlled hemorrhage without shock: no fluids necessary
 - Controlled hemorrhage with shock: Hespan 1,000 cc
 - Uncontrolled (intra-abdominal or thoracic) hemorrhage: no N fluid resuscitation
6. Inspect and dress wound
7. Check for additional wounds
8. Analgesia as necessary
 - Morphine: 5 mg N, wait 10 minutes; repeat as necessary
9. Splint fractures and recheck pulse
10. Antibiotics
 - Cefoxitin: 2 g slow-N push (over 3-5 minutes) for penetrating abdominal trauma, massive soft-tissue damage, open fractures, grossly contaminated wounds, or long delays before casualty evacuation
11. Cardiopulmonary resuscitation
 - Resuscitation on the battlefield for victims of blast or penetrating trauma who have no pulse, no respirations, and no other signs of life will not be successful and should not be attempted

Fig. 6. Basic tactical casualty management plan phase two: tactical field care.

wounds with the expectation of a re-engagement with hostile forces at any moment. The need to avoid undertaking nonessential diagnostic and therapeutic measures will be critical in such cases. At other times, care may be rendered once the patrol has reached an anticipated extraction point without pursuing forces and is awaiting the arrival of a tactical SOF helicopter. In this circumstance, there may be ample time to render without haste whatever care is feasible in the field. The time prior to extraction may range from half an hour or less to many hours. Another possibility is for the injury to occur before the presence of the patrol is known to the enemy, which would require that the mission commander make a decision about whether or not the operation should be continued and, if so, what to do with the casualty for the balance of the mission prior to CASEVAC. Although the patient and provider are now in a somewhat less hazardous setting, the tactical field care phase is still not the time or place for some of the procedures taught in ATLS, since the patrol will still typically be in the dark and operating in extremely non-sterile field conditions. Procedures such as diagnostic peritoneal lavage and pericardiocentesis obviously have no place in this environment.

If a victim of blast or penetrating injury is found to be without pulse, respiration, or other signs of life, cardiopulmonary resuscitation on the battlefield will not be successful and should not be attempted. Attempts to resuscitate trauma patients in arrest have been found to be futile even in the urban setting where the victim is in close proximity to trauma centers. One study reported no survivors out of 138 trauma patients who suffered a prehospital cardiac arrest and in whom resuscitation was attempted.⁴¹ The authors of that study recommended that trauma patients in cardiopulmonary arrest not be transported emergently to a trauma center even in a civilian setting because of the large economic cost of treatment for these patients without a significant chance for survival. On the battlefield, the cost of attempting to perform cardiopulmonary resuscitation on casualties with what are inevitably fatal injuries will be measured in additional lives lost as care is withheld from patients with less severe injuries and as operators are exposed to additional hazard from hostile fire because of their attempts. Only in the case of non-traumatic disorders such as hypothermia, near-drowning, or electrocution should cardiopulmonary resuscitation be considered prior to the CASEVAC phase.

As taught in ATLS, attention is first directed to evaluation of airway, breathing, and circulation. There should be no attempt at airway intervention if the patient is conscious and breathing well on his own. If the patient is unconscious, the cause will most likely be hemorrhagic shock or penetrating head trauma. The airway should be opened with the chin-lift or jaw-thrust maneuver without worrying about cervical spine immobilization, as noted previously. If spontaneous respirations are present and there is no respiratory distress, an adequate airway may be maintained in an unconscious patient in most cases by the insertion of a nasopharyngeal airway. This device has the advantage of being better tolerated than an oropharyngeal airway should the patient subsequently regain consciousness and being less likely to be dislodged during patient transport. A suspected fracture of the cribriform plate might be a relative contraindication to the use of a nasopharyngeal airway, but this

injury would be expected to be uncommon on the battlefield except in the case of massive head trauma, which would make survival unlikely.

Should an unconscious patient develop an airway obstruction, the nasopharyngeal airway may need to be replaced with a more definitive airway. Endotracheal intubation is the preferred airway technique in civilian emergency departments, and the ability of experienced paramedical personnel to master this skill has been well documented.^{4,5,42-52} A number of additional factors must be considered in the SOF battlefield setting, however: (1) the authors could find no studies that documented the ability of well-trained but relatively inexperienced paramedical military intubationists to accomplish endotracheal intubation on the battlefield; (2) many SOF corpsmen and medics have never performed an intubation on a live patient or even a cadaver; (3) endotracheal intubation entails the use of the white light in the laryngoscope on the battlefield; (4) maxillofacial injuries that result in blood and other obstructions in the airway would render endotracheal intubation extremely difficult and are probably best managed by cricothyroidotomy²¹; and (5) esophageal intubations would be much less likely to be recognized on the battlefield and may result in fatalities. Endotracheal intubation may be difficult to accomplish even in the hands of more experienced paramedical personnel under less austere conditions.⁵³ One study that examined first-time intubationists trained with manikin intubations alone noted an initial success rate of only 42% in the ideal confines of the operating room with paralyzed patients.⁴⁹ Most of the previously cited studies documenting the success of paramedical personnel in performing endotracheal intubation noted that cadaver training, operating room intubations, supervised initial intubations, or a combination of these methods were used in the training of paramedics. They also stressed the importance of continued practice of this skill in maintaining proficiency.

Cricothyroidotomy is the other airway option. This procedure has been reported to be safe and effective in trauma victims.⁵⁴ Although it would typically be attempted only after failed endotracheal intubation, in the hands of corpsmen or medics who do not intubate on a regular basis it is probably appropriate to consider this as the next step when a nasopharyngeal airway is not effective. It may be the only feasible alternative for any potential intubationist in cases of maxillofacial wounds in which blood or disrupted anatomy precludes visualization of the vocal cords.^{21,54} This procedure is not without complications,^{55,56} but SOF corpsmen are all trained in this technique and a prepackaged SOF cricothyroidotomy kit that contains the equipment for an over-the-wire technique is currently under development.

If blood or other obstructions are present in the oropharynx, they should be removed by hand or battery-powered suction. Oxygen is not usually appropriate for this phase of care because cylinders of compressed gas and the associated equipment for supplying the oxygen to the patient are too heavy to make their use in the field feasible on direct-action operations where they must be carried by the corpsman or medic.

Attention should next be directed toward the patients breathing. Progressive, severe respiratory distress on the battlefield resulting from unilateral penetrating chest trauma should be considered to represent a tension pneumothorax and that hemi-

thorax decompressed **with** a **14-gauge** catheter. The diagnosis in this setting should not rely on such typical clinical signs as breath sounds, tracheal shift, and **hyperresonance** on percussion because these signs may not always be **present**,⁵⁷ and even if they are, they may be exceedingly **difficult** to appreciate on the battlefield. A patient with penetrating chest trauma will generally have some degree of hemo/pneumothorax as a result of his primary wound, and the additional trauma caused by a needle thoracostomy would not be expected to significantly worsen his condition should he not actually have a tension **pneumothorax**.⁵¹ All Special Operations corpsmen and medics are trained in this technique: it is technically easy to perform and may be lifesaving **if** the patient does in fact have a tension pneumothorax. Paramedics are authorized to perform needle thoracostomy in some civilian emergency medical **services**.^{46,51} The decompression should be carried out with a needle and catheter so that the catheter may be taped in place to prevent recurrence of the tension pneumothorax. Chest tubes are not recommended in this phase of care because (1) they are not needed to provide initial treatment for a tension pneumothorax; (2) they are more **difficult** and time-consuming for inexperienced medical personnel to perform, especially in the absence of adequate light; (3) they are more likely to cause additional tissue damage and subsequent infection than a less traumatic procedure; and (4) no documentation was found in the literature that demonstrated a benefit from tube thoracostomy performed by paramedical personnel on the battlefield. One Israeli study reported 16 patients in whom chest tubes were placed by physicians in the field. One patient suffered an iatrogenic pneumothorax, 3 patients received chest tubes that were "clearly unnecessary," and 4 patients were found to have had their chest tubes inserted **subcutaneously**.⁵⁸ Tube thoracostomy is generally not part of the paramedic's scope of care even in less austere civilian emergency medical service **settings**.^{46,51}

Should the patient be found to have a major traumatic defect of the chest wall, the wound should be covered with a **petrolatum** gauze and a battle dressing. It is not necessary to vent one side of the wound dressing, since this is **difficult** to do reliably in a combat setting. If the casualty develops a tension pneumothorax after treatment, it should be decompressed as described above. Other wound dressings such as an **Asherman** valve may be reasonable and easy-to-apply alternatives.

The corpsman or medic should now address any **significant** bleeding sites not previously controlled. He should remove only the absolute minimum of clothing required to expose and treat **injuries**,²¹ both because of time constraints and the need to continue to protect the patient against the environment. Significant bleeding should be stopped as quickly as possible, using a tourniquet without hesitation as described previously to gain initial control of the bleeding. Once **the** patient has been transported to the site where extraction is anticipated, consideration should be given to loosening or removing the tourniquet and using direct pressure to control bleeding if this is feasible.

Intravenous (IV) access should be obtained next. Although ATLS recommends starting two large-bore (14 or 16 gauge) **IVs**,¹ the use of an **18-gauge** catheter is preferred in the field setting because of the increased ease of starting. The larger catheters are needed to be able to administer large volumes of blood products rapidly. This is not a factor in the tactical setting, since

blood products will not be available. One liter of lactated Ringer's solution can be administered through a **2-inch, 18-gauge** catheter in approximately 17 minutes without supplemental bag pressure compared to approximately 11 minutes with a **2-inch, 16-gauge catheter**.^{59,60} Although larger-gauge IVs may then have to be started later on when the patient arrives at an MTF, it is common practice to discontinue prehospital **IVs** upon arrival at a **definitive** treatment facility because of concern about contamination of the IV **site**.⁶¹

The corpsman or medic should ensure that the IV is not started on an extremity distal to a significant wound. Cleaning the skin before venipuncture is optional in the field. Subclavian and internal jugular venipunctures are not appropriate on the battlefield because of the potential for complications from these procedures.³¹ Should IV access in an upper extremity be a problem, an IV should be started in the saphenous or external jugular vein. If this also proves unsuccessful or infeasible, femoral venipuncture should be performed instead of trying to do a **shutdown** in the field.

Heparin or saline lock-type access tubing should be used unless the patient requires immediate fluid resuscitation as discussed below. This provides intravenous access for medications and later fluid resuscitation if required, but eliminates the logistical difficulties of managing the IV bag during transport and decreases the likelihood of the IV line becoming fouled and traumatically dislodged. Whenever a medication is given through a saline lock, the lock should be flushed with 5 cc of normal saline. Flushing the lock with normal saline approximately every 2 hours will usually **suffice** to keep it open without having to use heparinized solution.

Despite its widespread use, the benefit of prehospital fluid resuscitation in trauma patients has not been **established**.^{5-7,9-11,13,15,18,20,21,24-27,29,62} The **beneficial** effect from crystalloid and colloid fluid resuscitation in hemorrhagic shock has been demonstrated largely on animal models in which the volume of hemorrhage is controlled experimentally and resuscitation is initiated after the hemorrhage has been stopped.^{20,22,25,63,64} The animal data from a variety of uncontrolled hemorrhage models has clearly established that aggressive fluid resuscitation in the setting of an unrepaired vascular injury is either of no benefit or results in an increase in blood loss and/or mortality when compared to no fluid resuscitation or hypotensive **resuscitation**.^{8,9,14,16,18-20,26,27,65-68} **Hypotension** has been postulated to be an important factor in thrombus formation in uncontrolled hemorrhage **models**.⁶⁹ The deleterious effect of aggressive fluid resuscitation in these models may be due to interference with thrombus formation or other physiologic compensatory mechanisms as the body attempts to adjust to the loss of blood volume. Several studies noted that only after previously uncontrolled hemorrhage was stopped did fluid resuscitation prove to be of **benefit**.^{68,70,1} Only two studies were found that suggested that fluid resuscitation may be of benefit in uncontrolled **hemorrhage**.^{72,73} Both used rat-tail amputation models. One study found that no fluid resuscitation, **large-volume** normal saline resuscitation, and a combination of hypertonic saline and large-volume normal saline resulted in mortalities of 22, 0, and 11%, **respectively**.⁷² The other found that the infusion of 80 ml/kg of lactated Ringer's solution decreased mortality from 73 to 53%.⁷³

There have been several studies that addressed the issue of prehospital fluid resuscitation in humans. In his observations of combat trauma patients in World War I, Cannon concluded that initiating IV fluid replacement without first obtaining surgical hemostasis promoted further hemorrhage.⁷⁴ One large study of 6,855 trauma patients found that although hypotension was associated with a significantly higher mortality rate in trauma patients, the administration of prehospital IV fluids did not influence this rate.¹³ This study did not specifically address subgroups with controlled versus uncontrolled hemorrhage. Another paper discussed a retrospective analysis of patients with ruptured abdominal aortic aneurysms and hypotension that showed a survival rate of 30% in patients who were treated with aggressive preoperative colloid fluid replacement; in contrast, the author reported a survival rate of 46% in 40 hypotensive patients with ruptured abdominal aortic aneurysms who were given only enough fluid to maintain a systolic blood pressure of 50 to 70 mm Hg until the time of operative repair.⁷⁵ The author strongly recommends that aggressive fluid resuscitation be withheld until the time of surgery in these patients. A large prospective trial examining this issue in 598 patients with penetrating torso trauma and hypotension was recently published by Bickell and colleagues.³ They found that aggressive preoperative fluid resuscitation resulted in a survival rate of 62%. In those patients for whom aggressive fluid replacement was withheld until the time of operative intervention, the survival rate of 70% was significantly higher. The mean preoperative fluid volumes were 2,478 ml of Ringer's acetate for the immediate-resuscitation group and 375 ml for the delayed-resuscitation group. One consideration in applying the findings of this study to the battlefield environment is that the mean transport times to the trauma center were only 12 minutes for the immediate-resuscitation group and 13 minutes for the delayed-resuscitation group. Transport times from the battlefield to a medical treatment facility during an armed conflict would be expected to be much longer, and how this longer delay to operative intervention would affect the findings of the study is unknown. Some of the animal studies examining the value of fluid resuscitation on uncontrolled hemorrhagic shock, however, have had periods of observation after the induction of hemorrhage of 60 to 240 minutes and have still noted a beneficial effect from withholding fluid replacement in the setting of uncontrolled hemorrhage.^{8,14,16,18-20,26,65,66} Although the findings of Bickell and his colleagues await confirmation by other prospective studies, the weight of evidence at this time favors withholding aggressive IV fluid resuscitation in patients with uncontrolled hemorrhage from penetrating thoracic or abdominal trauma until the time of surgical intervention.

Immediate fluid resuscitation is still recommended for casualties on the battlefield whose hypovolemic shock is the result of bleeding from an extremity wound that has been controlled. Should the resuscitation fluid of choice for these patients still be lactated Ringer's or normal saline as taught in ATLS?

The first consideration in selecting a resuscitation fluid is whether to use a crystalloid or a colloid. **Crystalloids** are fluids such as lactated Ringer's and normal saline in which sodium is the primary osmotically active solute. Since sodium eventually distributes throughout the entire extracellular space, most of the fluid in crystalloid solutions remains in the Intravascular

space for only a very limited time. Colloids are solutions in which the primary osmotically active molecules are of greater molecular weight and do not readily pass through the capillary walls into the **interstitium**. These solutions are retained in the intravascular space for much longer periods of time than **crystalloids**. The **oncotic** pressure of colloid solutions may result in an expansion of the blood volume that is greater than the amount of fluid infused.

Most studies have shown crystalloids and colloids to be approximately equal in efficacy when used as an initial resuscitation fluid in hemorrhagic shock patients in the civilian trauma center setting.^{76,77} Given the lack of a demonstrated benefit from colloid solutions, the ATLS recommendation that fluid resuscitation be initiated with crystalloids is understandable when one realizes that the estimated annual savings in the United States from using crystalloids is approximately \$500 million.⁷⁷ The cost of 1 l of lactated Ringer's to a Naval Hospital in January 1996 was 61 cents as opposed to \$105.19 for 100 cc of 25% albumin and \$27.50 for 500 cc of 6% hetastarch (personal communication, LCDR Don Clemens, Pharmacy Department Head, Naval Hospital Pensacola).

When considering the prehospital environment in combat trauma, however, there is an additional consideration. In civilian settings, additional volume replacement therapy with blood components can be carried out shortly after the initial crystalloid therapy if necessary. Typical transport intervals for civilian ambulance systems are 15 minutes or less.^{3,6,13} With these very short transport intervals, most of the infused crystalloid is still in the intravascular space at the time of arrival at the trauma center.

Evacuation times for combat casualties are much longer. As recently as Operation Desert Storm, transport time to medical treatment facilities was found to range from 2 to 4 hours.⁷⁸ The time interval between initial treatment and arrival at an MTF for casualties in Special Operations may be much longer than this. The fluid expansion from crystalloid therapy would not be sustained for these periods of time. Lactated Ringer's solution equilibrates rapidly throughout the extracellular space, and by 1 hour after administration only approximately 200 cc of an initial infused volume of 1,000 cc will remain in the intravascular space.^{77,79,80} In contrast, 500 cc of a colloid such as 6% hetastarch results in an intravascular volume expansion of almost 800 cc⁷⁷ and this effect is sustained for at least 8 hours." In discussing resuscitation with colloids versus crystalloids, one paper notes that the more sustained effects of the colloid-containing solutions would be of greatest value if a substantial time interval separated acute resuscitation from subsequent efforts.⁸² A review paper on fluid resuscitation in traumatic hemorrhagic shock states that "there is almost universal agreement that colloid-containing fluids act more efficiently than crystalloid fluids to restore hemodynamic stability."⁸³

What do critical care texts say about crystalloids versus colloids in the resuscitation of patients in hypovolemic shock? One states that "when rapid expansion of the intravascular volume is desired, colloids are the clear choice."⁷⁷ Another states that colloids should be used any time that more than a 30% loss of blood volume must be replaced.⁷⁹

Even the ATLS manual states that crystalloids alone are insufficient for resuscitation of patients with blood loss of greater

than 30% of their blood volume (1500 cc).⁷ Since this amount of blood loss is required for a drop in blood pressure to be seen (class-III hemorrhage), another way to state this is that any patient who has a drop in blood pressure or altered sensorium due to hypovolemic shock will need more than crystalloid fluid therapy. Since it may be several hours or longer before blood component therapy can be initiated in combat trauma patients, it makes sense to use a blood volume expander whose effects will persist at least that long.

Having determined that colloid therapy may be more desirable in the setting of battlefield trauma, the next question is which colloid to use. Albumin was the primary colloid used for volume expansion for many of the early comparative studies. As noted previously, albumin is much more expensive than crystalloids. The synthetic colloids such as 6% hetastarch (**Hespan**) and the dextrans were developed as less expensive alternatives to albumin.^{77,84}

Hespan is composed of glucose polymers with an average molecular weight of 450,000. Although concerns have been voiced about coagulopathies associated with the use of **Hespan**,⁸⁵⁻⁸⁷ these effects are generally not clinically significant and are not seen with infusion volumes of less than 1,500 cc.^{77,79,83,87,88} An adverse effect of **Hespan** on immune function has been suggested,⁸⁹ but **Hespan** was observed to have a beneficial effect on macrophage function in another study, which examined its use as a resuscitation fluid in a mouse model of hemorrhagic shock.⁹⁰ Allergic reactions may occur, but are rare. The incidence of severe reactions is less than 1 in 10,000.⁷⁹ Serum amylase levels rise after hetastarch administration, but this is a normal response caused by the degradation of the hetastarch and is not an indication of pancreatitis.^{77,79}

The dextrans are also synthetic glucose polymers. Two types of dextran are available: dextran 40, with an average molecular weight of 40,000, and dextrose 70, with an average molecular weight of 70,000. The dextrans have an intravascular volume expansion that is similar to that of hetastarch⁷⁷ and are currently less expensive than **Hespan**, costing approximately \$15 per 500 cc. Side effects of the dextrans include acute renal failure, inhibition of platelet aggregation, allergic reactions, and interference with blood cross-matching.^{77,79,84} Acute renal failure is stated to be more likely in patients with decreased renal perfusion,^{77,79} which trauma patients in hemorrhagic shock may be expected to have. The interference with cross-matching for blood products is also a problem in the combat setting, since most of the patients who require fluid resuscitation in the field may be expected to require transfusion upon arrival at an MTF.

Hypertonic saline has been shown to be effective as an initial resuscitation fluid,^{79,82,91,92} but since hypertonic saline is a crystalloid, its effects when used alone are very short-lived.^{77,79,82} Studies examining the use of hypertonic saline have often combined it with a dextran to obtain a more prolonged effect,^{11,79,93-95} and this combination would then entail the same side effects mentioned previously for the dextrans.

Shelf-life and storage requirements are important considerations for resuscitation fluids to be used in military operations and are similar for **Hespan**, the dextrans, and lactated Ringers. The shelf-life of all three products is 2 years. All three products are recommended to be protected from freezing and from expo-

sure to temperatures above 104°F (sources: Abbott Laboratories for the dextrans and lactated Ringer's; Dupont Laboratories for **Hespan**).

One paper notes that the clotting abnormalities and allergic reactions seen with the dextrans have not been a problem with **Hespan**.⁸³ Another notes that **Hespan** is known to have the lowest rate of anaphylactoid complications when compared to the other colloids.⁹⁰ A third study states that dextran solutions are used for fluid resuscitation in Europe, but that **Hespan** is the synthetic colloid more commonly used in the United States.⁸²

In summary, then, the authors believe that hetastarch is the preferred fluid for initial colloid resuscitation, since it is less expensive than albumin and has less significant side effects than the dextrans. Several papers have found **Hespan** to be a safe and effective alternative to lactated Ringer's solution in resuscitating patients with hemorrhagic hypovolemia.^{79,83,96-100} Use of this fluid as a prehospital alternative to lactated Ringer's has been previously proposed in both the Army (personal communication, MAJ Lou Guzzi, Walter Reed Army Institute of Research) and the Air Force (personal communication, COL Dave Hammer, Air Force Special Operations Command).

What will the operator in the field notice from using **Hespan** instead of lactated Ringer's? Assume that one wishes to replace a 1,500-cc blood loss on the battlefield and have this effect be sustained for 4 hours or longer. By examining the distribution of these two fluids described earlier, we see that this degree of volume expansion may be obtained with 1,000 cc of **Hespan** (2 pounds), but it would take approximately 8 l of lactated Ringer's (almost 18 pounds) to achieve the same effect. This is a clinically significant weight reduction if one proposes to carry these fluids for long distances.

How much fluid should be given to a patient in shock on the battlefield? Precise quantification of blood loss in this setting based on observation will be difficult, but at least 1,500 cc of blood loss is required to produce the signs and symptoms of hemorrhagic shock. In a patient with shock and controlled hemorrhage, 1,000 cc of **Hespan** should be administered initially. Subsequent fluid administration should be titrated to achieve a good peripheral pulse and an improvement in sensorium rather than to normalize blood pressure. The amount of **Hespan** administered should generally not exceed 1,500 cc.

Once fluid resuscitation has been initiated, the corpsman or medic should cover the major wounds with appropriate battle dressings to minimize further contamination and to promote hemostasis. A careful check for additional wounds should be made, since the high-velocity projectiles from assault rifles may tumble and take erratic courses when traveling through tissue,¹⁰¹ often leading to exit sites remote from the entry wound.

If the casualty is conscious and requires analgesia, it should be achieved with morphine, administered intravenously if possible. This mode of administration allows for much more rapid onset of analgesia and for more effective titration of dosage than intramuscular administration. An initial dose of 5 mg is given and repeated at 10-minute intervals until adequate analgesia is achieved. The IV port nearest the site of the venipuncture should be used and the IV opened for about 15 seconds after the medication is injected or, if a saline lock is used, it should be flushed with 5 cc of normal saline. Morphine may be adminis-

tered intramuscularly if there is difficulty in starting an N. The initial dose should be 8 mg and the waiting period before additional doses if necessary is 45 to 60 minutes. There should be some readily visible indication of the dose and time of morphine administered, so that additional injections will not result in an overdose. It is important for the corpsman or medic to remember the contraindications to morphine use: unconsciousness, hypovolemic shock with a decreased level of consciousness, head injury, and respiratory distress.

Toradol is a commonly used alternative to narcotics for relief of moderate to severe pain, but this medication interferes with platelet function and hemostasis^{102,103} and should not be used in penetrating trauma patients.¹⁰⁴ SOF operators should also probably not be given any aspirin, ibuprofen, or other non-steroidal anti-inflammatory drugs while in theater because of their detrimental effects on hemostasis. Acetaminophen is a better alternative for control of minor pain in troops who are at ongoing risk of sustaining combat trauma.

Fractures should be splinted as circumstances allow, ensuring that peripheral pulses are checked both before and after splinting and that any decrease in the pulse caused by the splinting is remedied by adjusting the position of splint.

Infection is an important late cause of morbidity and mortality in wounds sustained on the battlefield. Cefoxitin (2 g N) is an accepted monotherapeutic agent for empiric treatment of abdominal sepsis¹⁰⁵ and should be given to all patients with penetrating abdominal trauma.^{21,106,107} Cefoxitin is effective against Gram-positive aerobes (except some Enterococcus species) and Gram-negative aerobes (except for some Pseudomonas species). It also has good activity against anaerobes (including *Bacteroides* and *Clostridium* species).¹⁰² Since it is effective against the clostridial species that cause gas gangrene, cefoxitin is also recommended for casualties who sustain wounds with massive soft-tissue damage,¹⁰⁷ grossly contaminated wounds, open fractures, or in whom a long delay until CASEVAC is anticipated.¹⁰⁸ Cefoxitin is supplied as a dry powder that must be reconstituted with 10 cc of sterile water for injection before administration. It may be given slow N push over 3 to 5 minutes,¹⁰² which eliminates the need for making piggyback solutions. The heparin lock or N should then be flushed as described previously. Cefoxitin may also be given intramuscularly (mix with 4 cc of sterile water) in the upper outer quadrant of the buttock if necessary.¹⁰² The risk of allergic reactions to cephalosporins has been found to be low in supposed penicillin-allergic patients,^{109,110} and use of cephalosporins in these patients is not necessarily felt to be contraindicated unless there is a history of an immediate or severe anaphylactic reaction to penicillin.¹¹¹ Additional doses should be administered at 6-hour intervals until the patient arrives at a treatment facility. For individuals with a history of penicillin allergy that is felt to contraindicate the use of cephalosporins, other broad-spectrum antibiotics should be selected in the planning phase of the mission.

CASEVAC Care

At some point in the operation, the mission personnel will be recovered onto a helicopter, naval craft, or other asset to be extracted from the combat environment. As mentioned previously, the time to extraction for a direct-action SOF mission may be quite variable, but will most often be in the 30-minute to

several-hour range from the time that expedited extraction is requested. Generally, the other mission personnel will be extracted at the same time as the casualties.

It is important to mention an interservice difference in terminology at this point. It is common to hear Navy and Army personnel refer to a "MEDEVAC" when describing the air evacuation of wounded combat personnel from the battlefield. In the Special Operations arena, this evacuation will often be carried out by Air Force Special Operations Command tactical rotary wing assets, such as the MH 53 Pave Low helicopter. The Air Force, however, considers the term "MEDEVAC" to be reserved for the aeromedical evacuation of a stable patient from one medical treatment facility to another.¹² The more medically sophisticated assets that the Air Force uses for MEDEVACs do not have the armor or weapons systems to be used in combat scenarios where the threat of hostile fire is high. Thus, we recommend that the term MEDEVAC be avoided when discussing the initial management of combat casualties and the term "combat casualty evacuation," or CASEVAC, be used instead to eliminate any misunderstanding of the mission required.

Two significant differences will be present in progressing from the tactical field care phase to the CASEVAC phase. The first is that additional medical personnel may accompany the evacuating asset. Current practice in Special Operations is that medical care during CASEVAC is expected to be rendered by the corpsman or medic present on the mission phase of the operation. This is a problem for several reasons: (1) the corpsman or medic may be among the casualties; (2) the corpsman or medic may be dehydrated, hypothermic, or otherwise debilitated; (3) the CASEVAC asset's medical equipment will need to be prepared prior to the extraction mission; and (4) there may be multiple casualties that exceed the ability of the corpsman or medic to care for simultaneously.

A more desirable arrangement would be the establishment of combat casualty transport teams (CCTTs) to be deployed with CASEVAC assets in theater for extractions with casualties. It is possible to have more highly trained and experienced medical personnel at this point of the operation, and this opportunity should not go to waste.¹² The composition of these teams has not been resolved at this point, but probably the best arrangement would be a two-person team composed of an Air Force aviation medic who is familiar with the particular airframe to be used and a physician with as much recent trauma or critical care experience as possible. If a naval craft is the designated evacuation asset, a Naval Special Warfare corpsman would be substituted for the aviation medic. The physician in both cases should preferably be a practicing emergency medicine or critical care specialist designated to provide medical augmentation support to Special Operations forces in theater, but might also be a physician organic to the SOF forces who has had recent experience in an urban trauma center. Although there may be times when more than two people would be useful, two is probably the most reasonable number because of space constraints within the evacuation asset and a scarcity of specialized medical personnel in theater. An expanded role for emergency medicine physicians was employed successfully in the prehospital care of casualties resulting from Operation Just Cause in Panama in 1991.¹¹³ To be effectively utilized in SOF operations, CCTTs would need to be formally designated in medical mobilization plans, receive initial training followed by subsequent refresher

training at least annually, and be assigned to the theater Special Operations commander in a conflict.

The second major difference in this phase of care is that additional medical equipment can be brought in with the CASEVAC asset and would not have to be carried in the tactical ground or water portions of the operation. Preparation of this equipment prior to operations should be the responsibility of the combat casualty transport team, since they do not have the responsibility of preparing medical equipment for the ground or water phases of the operation.

Designation of the receiving MTF should be coordinated with the theater commander-in-chief or Joint Task Force surgeon and may be a hospital ship, a Reld hospital, or other facility. Coordination to ensure that casualties are sent to the nearest and most appropriate MTF may be a problem in theater.¹¹⁴ Although it is desirable to take significantly wounded casualties directly to the MTF, holding areas may have to be used in some circumstances.¹¹⁵ Consideration should also be given to the possible need for a secondary evacuation asset, such as when recovery of the casualties is accomplished by a submarine or coastal patrol craft and the patient needs to be transported on an emergent basis to an MTF by helicopter after stabilization, or when tactical exigencies preclude the use of the planned extraction asset and an emergency helicopter extraction must be carried out. Coordination of all of these aspects of care would be best accomplished by a senior SOF medical officer assigned to the staff of the theater Special Operations commander and working in conjunction with the theater commander-in-chief surgeon.

The proposed management plan for the CASEVAC phase is presented in Figure 7. Many of the same principles of care outlined in the tactical field care phase will also apply to this phase, and only significant differences between the two will be addressed in this section. The designation of CCTTs will provide for more experienced intubationists so that an optimum airway might be more easily achieved in this phase of care. Placement of the endotracheal tube in the trachea may be confirmed with capnography in this setting.^{116,117} A cricothyroidotomy remains an option if intubation cannot be accomplished. Many tactical aircraft have restrictions against the presence of a white light in the cabin during a combat action, so the issue of the white light on standard laryngoscopes should be reviewed with the aircraft commander beforehand.

The laryngeal mask airway (LMA) is a device that is designed to be inserted blindly and cover the laryngeal inlet. It has been commercially available in the United Kingdom since 1988 and was approved by the Food and Drug Administration for use in the United States in 1992. The LMA is gaining increasing acceptance as an alternative to tracheal intubation for short surgical procedures.¹¹⁸⁻¹²⁰ This device does not require the use of a laryngoscope with its potentially compromising white light. It has been found to be more quickly and reliably inserted than an endotracheal tube by paramedics and respiratory therapists.⁵³ Another study by Leach et al. found that placement of an LMA was successful in 39 of 41 attempts by nursing staff and operating department assistants, including 3 instances when attempts at intubation had been unsuccessful.¹²¹ The LMA has the disadvantage of offering somewhat less protection against aspiration of stomach contents,^{119,122} but most participants in

<ol style="list-style-type: none"> 1. Airway management <ul style="list-style-type: none"> Chin-lift or jaw-thrust Unconscious casualty without airway obstruction: <ul style="list-style-type: none"> nasopharyngeal airway, endotracheal intubation, Combitube or laryngeal mask airway Unconscious casualty with airway obstruction: <ul style="list-style-type: none"> cricothyroidotomy if endotracheal intubation and/or other airway devices are unsuccessful 2. Breathing <ul style="list-style-type: none"> Consider tension pneumothorax and decompress with needle thoracostomy if a casualty has unilateral penetrating chest trauma and progressive respiratory distress Consider chest tube insertion if a suspected tension pneumothorax is not relieved by needle thoracostomy Oxygen 3. Bleeding <ul style="list-style-type: none"> Consider removing tourniquets and using direct pressure to control bleeding if possible 4. N <ul style="list-style-type: none"> Start an 18-gauge N or saline lock if not already done 5. Fluid resuscitation <ul style="list-style-type: none"> No hemorrhage or controlled hemorrhage without shock: <ul style="list-style-type: none"> lactated Ringer's at 250 cc/hour Controlled hemorrhage with shock: Hespan 1,000 cc initially Uncontrolled (intra-abdominal or thoracic) hemorrhage: no N fluid resuscitation Head wound patient <ul style="list-style-type: none"> Hespan at minimal flow to maintain infusion unless there is concurrent controlled hemorrhagic shock 6. Monitoring <ul style="list-style-type: none"> Institute electronic monitoring of heart rate, blood pressure, and hemoglobin oxygen saturation 7. Inspect and dress wound if not already done 8. Check for additional wounds 9. Analgesia as necessary <ul style="list-style-type: none"> Morphine: 5 mg IV; wait 10 minutes; repeat as necessary 10. Splint fractures and recheck pulse if not already done 11. Antibiotics (if not already given) <ul style="list-style-type: none"> Cefoxitin: 2 g slow N push (over 3-5 minutes) for penetrating abdominal trauma, massive soft-tissue damage, open fractures, grossly contaminated wounds, or long delays before casualty evacuation

Fig. 7. Basic tactical casualty management plan phase three: combat casualty evacuation (CASEVAC) care.

Special Operations direct-action missions will have been effectively fasting by the time a wound is sustained in combat.¹³ Use of the LMA by ward nurses in a multi-center study was found to be associated with only a 2% incidence of regurgitation in cardiac arrest patients who had not been fasting prior to the insertion of the LMA,¹²³ and Leach noted no aspiration of stomach contents in his series.¹²¹

Another airway device that has proven successful as an alternative to endotracheal intubation is the esophageal tracheal Combitube.¹²⁴ This device has been found to provide adequate ventilation and can be inserted without the need for illuminated laryngoscopy.¹²⁵ The Combitube has been found to be useful in establishing an airway when intubation is impossible because of vomiting or other airway obstruction.^{126,127} Two studies that evaluated the use of the Combitube by paramedics in prehospital cardiac arrest found it to be effective both as a primary airway and as a backup to endotracheal intubation.^{128,129}

Neither the Combitube nor the LMA are currently included in the airway section of ATLS.¹ Both of these devices show promise as alternatives to endotracheal intubation in the tactical setting but cannot be recommended for general use in Special Operations at this time because not all SOF corpsmen and medics have been trained in their use. Both devices should be evaluated as potential additions to the SOF combat care equipment list and added to the SOMTC curriculum if appropriate.

Helicopter transport impairs or precludes the provider's ability to auscultate the lungs^{130,131} or even to palpate the carotid pulse.¹³² Electronic monitoring systems capable of providing blood pressure, heart rate, pulse oximetry, and capnography are commercially available and needed for air medical transport. The presence of an esophageal intubation will have to be noted by a decrease in the O₂ saturation or an absence of expired CO₂ after intubation, since it will be impossible to hear breath sounds in this setting. The use of pulse oximetry will also help to avoid hypoxia while performing endotracheal intubation.¹³³ It is not necessary to place hypotensive casualties in the Trendelenburg position for transport,¹³⁴ but they should be maintained in the horizontal position when possible.

Transport of casualties in high-speed Special Operations boats also renders auscultation and palpation difficult or impossible, but the presence of frequent splash exposures and high-acceleration impacts makes electronic monitoring infeasible in this environment. Additionally, protection of patients from impact trauma during transport is a major factor in high-speed boat casualty evacuation.

Oxygen should be administered to seriously injured patients during this phase of care. Oxygen generation systems that use chemical reactions to generate oxygen are available for use on aircraft. Compressed-gas bottles are less desirable for aircraft use because of the possibility of ballistic damage to the cylinder resulting in explosive decompression and possible injury to aircraft passengers or damage to the aircraft itself. Tube thoracostomy is a reasonable option in this phase of care since there should now be a physician experienced in this technique present and a more favorable environment in which to perform it.

Patients with controlled hemorrhagic shock may be resuscitated with Hespán to a mean arterial pressure of 60 to 80 mm Hg in this phase, since more precise electronic monitoring should now be available. Casualties with penetrating chest wounds or abdominal wounds should still probably not be aggressively fluid resuscitated, although this decision may be more individualized in the CASEVAC phase by a physician skilled in dealing with trauma patients. An IV rate of 250 cc per hour for patients not in shock will help to reverse mild dehydration and prepare them for possible general anesthesia once they arrive at the medical treatment facility. Lactated Ringer's solution may be used for fluid resuscitation in these patients because there are no restrictions on weight in this phase and sustained intravascular volume expansion is less critical. Patients with head injuries should receive Hespán at only the minimal flow to maintain perfusion unless there is concurrent hypovolemic shock. Blood products may be a possibility in some cases during helicopter transport.

Military antishock trousers (MAST) have been reported to be of benefit in animal models of hemorrhagic shock and in some

severely hypotensive patients with abdominal or pelvic hemorrhage,^{72,135-138} but these findings have been disputed by other studies.¹³⁹⁻¹⁴⁰ One large prospective trial found a significantly higher incidence of mortality in the group treated with MAST.¹⁴⁰ The benefit of this device remains controversial, and MAST are currently being de-emphasized in ATLS. No studies were found that evaluated their efficacy in a battlefield casualty evacuation setting. MAST were not recommended for use by Army medical personnel during Operation Desert Storm²¹ and should not be considered standard equipment for SOF CASEVAC care. This device should not be used if there is penetrating thoracic trauma or if a traumatic disruption of the diaphragm is suspected. If applied, it should not be removed until the patient is ready for definitive corrective surgery at an MTF. If evacuation is carried out by helicopter at altitudes above 1,000 to 2,000 feet, the garment should be monitored for changes in effect as a result of decreasing atmospheric pressure and resultant expansion of the garment.

No attempt should be made during transport to debride or otherwise repair the wounds sustained. The darkness and instability of a tactical rotary wing aircraft combined with the contaminated and crowded conditions that will usually exist make such efforts inadvisable even when individuals with surgical experience are present. Debridement of assault rifle wounds was shown in one study to be of less benefit to wound healing than previously thought,¹⁴¹ and in any event, these maneuvers are best deferred until the casualties arrive at the treatment facility.

Combat Casualty Care Scenarios

Having established a general plan with which to approach injuries that occur in a tactical environment, let us now return to the casualty scenarios presented earlier and examine what tactical considerations and modifications to the basic management plan may be required for each particular scenario.

Scenario 1

Figure 1 describes a casualty that might occur on a combat swimmer mission. The most profound difference from the basic management guidelines imposed by this scenario is the obvious difficulty involved in taking care of casualties that occur in the water. A combat swimmer in this circumstance will probably be killed by additional fire from the patrol boat unless he resurfaces. In addition, if he remains on the surface, the presence of combat swimmers in the target area will be confirmed, where otherwise the patrol boat personnel might think the momentary sighting of an object in the water to have been a seal of the aquatic mammal variety. The most appropriate thing to do in the care under fire phase here is for the injured diver and his buddy to resurface immediately. Moments of indecision at this juncture may well prove fatal to both members of the swim pair and to the mission as well. It is not realistic to expect the two divers to continue their attack with a seriously wounded person, and there is little in the way of medical care that can be provided to the casualty as the divers swim away from the target area. The hyperbaric oxygen from the diver's closed-circuit oxygen SCUBA rig may help with his oxygenation status, and the tight neoprene rubber of the wet suit may help close the wound. The uninjured

diver should be alert for a possible loss of consciousness on the part of the injured diver while swimming away from the target area. If the casualty does subsequently lose consciousness, his swim partner should try to surface if this is now tactically feasible, since an unconscious diver is in grave danger of aspiration of sea water and death from drowning. The rescue diver must watch his depth control very carefully while assisting an unconscious or disabled buddy, since a downward depth excursion may result in his suffering a convulsion from central nervous system oxygen toxicity, and an upward excursion may cause a potentially fatal inadvertent surfacing.

Once the injured diver has been taken back to a rendezvous site where the pair can be picked up by the rubber Zodiac boat, an additional measure of care can be provided. The patient can then be treated according to the standard treatment outline for the tactical field care phase, assuming that the mission planners have arranged for medical equipment to be placed in the Zodiac. The patient should be monitored carefully for a possible tension pneumothorax after he has been brought to the surface, since the decrease in ambient pressure may cause expansion of gas in the pleural space. Arterial gas embolism is also a possibility in this setting. The more complete treatment measures found in the CASEVAC phase may be accomplished when the swimmers have returned to the larger coastal patrol craft. Recompression should also be considered if the patient's clinical picture suggests an arterial gas embolism.

Scenario 2

Figure 2 describes an injury occurring on a parachute insertion. The medical management of this injury is much simpler. There is no care under fire phase to deal with. Tactical field care is appropriately covered by the basic protocol. The question now is the command decision of if and how the mission should proceed. One tactical option after the injury would be to carry the casualty with the patrol as it continues toward the objective. The temptation to attempt this maneuver would be strong in a Special Operations unit with physically powerful individuals, but this would be a very difficult thing to do and still maintain tactical speed, vigilance, and fire coverage. It would most likely make for a noisier patrol as well and could be expected to be extremely painful for the casualty. Consideration would have to be given to equipment, weapon, and ammunition management for both the casualty and the transporting member of the patrol. Another option might be to abort the operation and call for immediate extraction. In some circumstances, this might be a very reasonable choice, but on other missions there may be a perishable aspect to the intelligence so that a mission abort is not an option. A third choice would be to leave the casualty near the drop zone and arrange for an extraction coordinated with the assault phase of the operation. This has the attraction of allowing the mission to be accomplished, but requires the temporary leaving of a wounded comrade on the battlefield. It also raises the issue of whether or not the mission corpsman or medic will be left with the wounded man or accompany the patrol on the rest of the operation. Such tactical decisions will be made by the mission commander, but the corpsman or medic will need to know what that choice is expected to be in the mission-planning phase so that he may plan accordingly. The decision is made more difficult if one substitutes a life-threatening injury such as maxil-

lofacial trauma with airway compromise or blunt abdominal trauma with hypotension for the fractured extremity in this scenario.

Scenario 3

The scenario described in Figure 3 illustrates a typical operation in which casualties are sustained at or near the objective. The care under fire protocol is appropriate as previously described, as is that for tactical field care. The point at which the corpsman or medic stops to render care is a key issue here. Should the assault be pressed until hostile fire is totally suppressed before stopping to render care, or should the corpsman or medic be directed to render care immediately? How will the casualties be carried? (Don't forget the potential for additional booby traps.) Should the assault be discontinued as soon as the booby trap is encountered because of the potential for encountering additional such devices as you proceed? The riverine craft would be the primary extraction asset in this case; modifications to the basic CASEVAC management plan would probably have to be made because of the limited space on most such craft and the certainty of splash episodes onto whatever medical gear is brought on board. In addition, provision would have to be made for securing the casualties during a high-speed boat ride.

Scenario 4

Figure 4 describes a high-priority interdiction mission in progress when a patrol member suffers a snakebite. The injury does not compromise the presence of the patrol and there is no firefight, but there is now a conflict between continuing the mission and providing optimum care for the casualty. Ideally, the casualty should be immediately extracted and transported to a medical treatment facility, but this would preclude the opportunity to successfully complete the mission.

The casualty should not be allowed to walk or run, since this might promote dissemination of the venom. Tactical field care for the bite is an item of some dispute, with some advocates for incision and suction, others for a simple constricting band proximal to the bite, and yet others advocating the use of direct pressure applied over the bite site to reduce blood flow to the area and thereby reduce venom dissemination. Additional questions arise. Should patrols be expected to carry generic antivenom into the field for every operation? Should the patrol make the usual attempt to kill the snake and bring it to the medical treatment facility for identification? Considering the fact that shooting the snake is not an option in this scenario, nor is trying to club it to death with the butt end of a loaded automatic weapon, would it be better to simply note the size, color, marking patterns, and head shape of the snake? Some snakes display territoriality; should the ambush be moved to a different site to avoid further encounters with the offending reptile?

These scenarios illustrate the need for combat trauma management plans to be developed with the tactical context in mind. The appropriate care for a given casualty may vary based on the criticality of the mission, the time to evacuation, and many other factors that are unique to each mission in Special Operations. Management plans for combat trauma must be considered to be advisory rather than directive in nature, since rarely will an actual tactical situation exactly reflect the conditions outlined using such scenarios. Both the basic tactical combat casualty

care guidelines and the **specific** management plans must be reviewed periodically to ensure that they are changed to reflect medical advances and changes in tactical doctrine.

In summary, many of the problems involved in the treatment of combat casualties on the **battlefield** are unique to the military. We cannot expect that our civilian colleagues will be able to answer all of these questions for us **with** treatment methods designed for the urban trauma setting. The military medicine community needs to be aggressive in identifying differences between the civilian and combat circumstances and **modifying** treatment standards as indicated. Although ATLS training remains appropriate for military physicians and nurses, for combat medical personnel this training should be supplemented with guidelines that take tactical battlefield conditions into account. This paper presents a set of guidelines developed for a **specific** community at a specific point in time. Although they may have some applicability to other combat arms communities, the task of developing more general guidelines for battlefield trauma care in the military would be best accomplished by a standing panel established by the Assistant Secretary of Defense for Health Affairs with a specific charter to monitor developments in trauma care and periodically update these guidelines. Input from this panel could also be used to focus a portion of Department of Defense medical research expenditures on **specific** unresolved prehospital combat trauma care issues.

Recommendations

(1) Combat trauma sustained on direct-action **Special Operations** missions should be managed according to **the** guidelines described in this paper in the prehospital phase.

(2) ATLS-based training for Special Operations corpsmen and medics should be supplemented **with** training in these tactical combat casualty care guidelines.

(3) Planning for combat casualties in Special Operations should be based on specific mission scenarios to aid in **identifying** the unique medical and tactical issues that will have to be addressed in that scenario.

(4) SOF operators on combat missions should all have a **suitable** tourniquet readily available at a standard location on their battle gear and be trained in its use.

(5) Combat casualty transport teams should be designated and trained. In the event of a conflict, these teams should be assigned to the theater Special Operations commander.

(6) A senior medical officer from the SOF community should be assigned to the theater Special Operations commander during **conflicts** to assist in planning and coordination for treatment of medical casualties that occur during SOF missions.

(7) The laryngeal mask airway and the esophageal tracheal Combitube should be evaluated for use in the tactical combat casualty care setting and incorporated into SOF use if appropriate.

(8) Potential CASEVAC assets for SOF combat missions should be **identified** as part of the planning conducted by Special Operations theater commanders so that SOF mission commanders and Combat Casualty Transport Teams will be able to plan and train appropriately.

(9) The guidelines for tactical combat casualty care recommended in this paper for use by Special Operations forces on the battlefield should be reviewed by the combat arms of the other services for possible applicability to their tactical environments.

(10) The Assistant Secretary of Defense for Health Affairs should establish a standing panel tasked with the development and periodic review of tactically appropriate guidelines for the prehospital management of combat trauma. This panel should monitor new developments in the field of prehospital trauma care and incorporate them into updated guidelines that are appropriate for the tactical battlefield environment.

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